The Artificial Nature of Fluoridated Water:

Between Nations, Knowledge, and Material Flows

*By Christopher Sellers**

ABSTRACT

An exercise in "historical ontology," this paper charts the contrasting ways fluoridated water and its effects crystallized as objects of knowledge and concern in three quite different realms over the mid twentieth century. Among U.S. health officials and experts, fluoridated water emerged and stabilized as a public health goal, preventing tooth decay. Indian doctors and scientists defined it as a public health problem, causing "skeletal fluorosis." Fluoridated water also acquired an intense presence among laypeople in the United States, especially those voting in local referenda on fluoridation. More often than not rejecting it, suspecting bias and myopia in profluoridation expertise, they cobbled together a lay ontology that proved predictive of the varied and changing flows of fluoridated water itself. The paper concludes by suggesting a principle of environmental symmetry as an aid to this kind of comparative ontology.

INTRODUCTION

On January 25, 1945, the first fluoride-loaded drops of drinking water splashed through the faucets of Grand Rapids, Michigan. They bore the rising hopes of a handful of public health officials that fluoridation would prove a "magic bullet" remedy against tooth decay. Since the germ theory of the late nineteenth century inaugurated a new public health in the early twentieth century, few measures have so readily found their way into the American health officials' pantheon of global remedies. Fluoride's inhibiting effects on cavities had only become recognized by public health scientists in the 1930s, yet by the early fifties, years before the Grand Rapids experiment was over, water fluoridation had received endorsements from the American Medical Association, the American Dental Association, the American Public Health Association, and the U.S. Public Health Service, and a campaign was in full swing to bring it to the rest of the nation and world.[1]

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[1] Donald R. McNeil, *The Fight for Fluoridation* (New York, 1957); M. W. Easley, "Celebrating 50 Years of Fluoridation: A Public Health Success Story," *British Dental Journal* 178 (1995): 72–5; Greg

The achievements of the fluoridation campaign have fallen significantly short of those heady aspirations, however. The science justifying fluoridation, like the practice itself, has remained predominantly American. By the early sixties, the United States had fluoridated more water than the rest of the world combined (serving 46 million versus 25 million people). By the 1990s, that was no longer the case, but Americans still made up nearly half of those receiving fluoridated water worldwide (132.2 million of 298.2 million people).[2] Why have so many people been so hesitant about fluoridation? Social scientific answers to this question abound, but in this paper I want to suggest another answer involving the perceived ontology of fluoride itself. The "fluoride" of fluoridation scientists and advocates differed from the "fluoride" of many others around the world who ignored or blocked the practice.

Scientists outside the United States had concerns about fluoridation's universal value. For instance, prominent experts saw fluoride as a veritable disease menace in a place such as India. At the same time American investigators were making the case for fluoridation in drinking water as a health benefit, Indian scientists and doctors began linking fluoridated water to a mysterious, crippling bone malady, skeletal fluorosis. In the 1950s, as American public health officials strove for public support to build fluoridation plants, their Indian counterparts were desperately seeking ways of defluoridating local water supplies.

Skepticism about the universal value of fluoridation was not limited to non-American scientists. Despite the quick embrace by America's national organizations of health professionals, fluoridation stirred up an unusually vocal and effective lay opposition in the U.S. scientists' backyard. By the late 1950s, lay voters had quashed the idea in some 70–80 percent of fluoride referenda across the United States.[3] The fate of fluoridation offers a dramatic counterpoint to many historical characterizations of this midcentury era of American health history—such as Paul Starr's claim that doctors had achieved "cultural authority," or John Burnham's that this period capped a "Golden Age of Medicine."[4]

Setting the story of fluoridation in these wider contexts, global as well as inexpert, illuminates the parochialism of those midcentury American experts who made the case for fluoridation. They did so, in part, by bracketing out the questions about fluoride others continued to ask. Extending a project in science and medical history that Ian Hacking dubs "historical ontology," I chart the bumpy and divergent ways fluoridated water and its effects emerged and stabilized as contrasting objects of scientific concern in two very different national traditions of public health, only partly reconciled by the later mediation of the World Health Organization (WHO). Projected transnationally, the historical ontology approach to fluoride suggests a model for

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Field, "Flushing Poisons from the Body Politic: The Fluoride Controversy and American Political Culture," typed manuscript. See also Brian Martin, *Scientific Knowledge in Controversy: The Social Dynamics of the Fluoridation Debate* (Albany, N.Y., 1991).

[2] G. H. Leatherman and J. Ellis, "Fluoridation round the World" (1963), Folder "Fluoridation around the World," Box 1, Fluoride Papers, Epidemiology Dept. of National Institute of Dental Research, History of Medicine Division, National Library of Medicine, Bethesda, Md., Institute of Social Sciences, *Fluorosis in India* (New Delhi, 1992), 27; Public Health Service, Ad Hoc Subcommittee on Fluorine of the Committee to Coordinate Environmental Health and Related Programs, *Review of Fluorine Benefits and Risks* (Washington, D.C., 1991), 22.

[3] Robert Crain, Elihu Katz, and Donald Rosenthal, *The Politics of Community Conflict: The Fluoridation Decision* (Indianapolis, 1967), 22.

[4] Paul Starr, *The Social Transformation of American Medicine* (New York, 1982), especially 134–40; John C. Burnham, "American Medicine's Golden Age: What Happened to It?" *Science,* 19 March 1982, 1474–9.

health history akin to, yet distinct from, the "disease-frame" approach so popular among social and cultural historians. Instead of revolving around a particular disease, this story pivots around pathological interpretations of an environmental "risk factor," which disease-centered histories often marginalize or ignore.[5] In adapting this project of historical ontology to the history of environment and health, this story of fluoride pushes it in two other new directions.

While historical ontologists such as Hacking, Lorraine Daston, and Bruno Latour confine themselves to the historical "cocreation" of natural objects such as "bacteria" by experts and laboratories, the fate of fluoridation suggests the importance of extending this project beyond the purview of past scientists. What Daston terms the "quotidian," the realm of inexpert material experience turned out to be considerably less "obdurate," "enduring," or "obvious" than she asserts, for Indian villagers as well as lay American antifluoridationists. For these laypeople, fluoridated water remained, as Daston puts it for her scientists, "simultaneously real *and* historical," natural and constructed.[6] Indeed, what distinguished so many laypeople from profluoridation scientists and health professionals was that, for them, the artifice of putting fluoride in their faucets threatened realities that were more diverse and dire than these experts thought "realistic."

In reconstructing these historical ontologies of fluoride side by side, I also want to suggest a more eclectic approach to fluoride's own historical agency. Much as we learn from Latour and Daston about the "historicity of things," their strict focus on established expertise of a given era, in combination with a studied refusal to consider "travel *through* time of an already-existing *substance,*" steers them away from questions that help set fluoridation within a broader and longer history. How, for instance, might germs or fluoridated water, as historical "actors" or "influences," actually circumvent the frames of past experts, yet be seen, asserted, or imagined by nonexperts? How might the history of this environmental substance's actual distribution, flow, and changing human contacts have intersected with the ways fluoridated water has been conceived and debated? Historians of science and medicine may shrug off Latour's blanket attack on these questions, which says that by taking fluoride as an "already existing substance," they "accept too much of what the giants demand."[7] Still, the scholarly scope and emphasis of this edited volume reflect how difficult it has become to address such questions within the fields of science and medical history alone.

Positing some historical continuity to fluoride not only helps recover its diverse and changing flows but also raises more insistent questions about what laypeople knew. I draw here from environmental history, in which much recent scholarship has highlighted a materialist ecology of "flows," from streaming wheat and lumber into Chicago in William Cronon's work to Martin Melosi's history of urban channels of water and sewage to Joel Tarr's depiction of industrialization as "the search for the ultimate sink."[8] Material reconstruction of fluoride's shifting distribution—in part by

[5] Charles Rosenberg and Janet Golden, eds., *Framing Disease: Studies in Cultural History* (New Brunswick, N.J., 1993).

[6] Ian Hacking, *Historical Ontology* (Cambridge, Mass., 2002); Lorraine Daston, ed., *Biographies of Scientific Objects* (Chicago, 2000), 2–3; Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, Mass., 1999), especially 145–73.

[7] Latour, *Pandora's Hope* (cit. n. 6), 162.

[8] William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York, 1991); Martin Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore, 2000); Joel Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, Ohio, 1996).

drawing on more recent, "anachronistic" science—spotlights historical contingencies missed by a focus on past expert perceptions alone: stark differences in the "natural" fluoride concentrations between nations, as well as contrasts in the engineering of human water supplies. An ecological perspective on fluoride's history brings out longer-term, larger-scale consequences of the fluoridation campaign, including the worldwide rise in fluoride exposure over the late twentieth century. It also helps move nonscientists toward the center of the historical stage by reorienting our perspective toward encounters with "fluoridated" water that were less mediated by past fluoride experts.

THE SCIENCE OF FLUORIDE FOR U.S. WATERS: FROM NATURAL TO NORMAL

Fluoride-bearing minerals originate in the tumultuous heat of volcanoes and lava flows. They make up 1 percent of the earth's crust, mostly solidified into fluorspar or cryolite. Coming into contact with water, fluoride starts to flow again, to a degree that depends on the type and porosity of the rocks and the pH, temperature, and other chemical characteristics of the water, as well as flush rates. Not surprisingly, the natural concentration of fluoride in water fluctuates widely by climate and regional as well as local geography.[9] Within the United States, groundwater in the eastern and central sections of the country, where most people lived into the early twentieth century, often averaged less than 0.1 parts per million (ppm) of fluoride. In the rapidly growing western states more recently settled by whites, measured amounts of fluoride in the drinking water often ranged higher than 1ppm, in some places to as much as 16 ppm.

A combination of natural and built hydrology helped steer early U.S. fluoride researchers toward viewing fluoridated water as manipulable, whether as problem or remedy. By the time American health officials started investigating fluoride levels of drinking water, they disregarded "unreliable" water sources such as "isolate potholes" or streams, where sediments could elevate fluoride concentrations. Most of the communities under study had "reliable water suppl[ies]": deep wells and "sanitary" systems that filtered their drinking water and piped it into homes.[10]

The first American investigations into the fluoride content of water came as part of a concerted effort during the 1910s and '20s to discern the cause of a strange, unremovable brown stain on teeth, known as mottling. As eastern-trained Colorado Springs dentist Frederick McKay discovered, Colorado Brown Stain seemed endemic to dental patients in this and other recently-established western towns. He posed few or no questions about the existence of the stain among longest-standing locals such as Native Americans, instead seeking a "retrofit" for this condition mainly in the European medical literature. A 1901 report out of Naples, Italy, on volcano-contaminated groundwater led him to discount contributions from food or air early on. Following models in industrial hygiene and vitamin deficiency studies, correlating clinical with environmental information, McKay and a few like-minded investigators—chemists and physicians as well as dentists—concluded that waterborne fluoride was responsible. Only through extensive public debate did they convince lay citizens in towns

[9] Subcommittee on Fluorine, *Fluorine Benefits and Risks* (cit. n. 2), 2; on fluoride's history, see also Kaj Roholm, *Fluorine Intoxication: A Clinical-Hygienic Study* (Copenhagen, 1937), 7–60.

[10] World Health Organization (WHO), *Fluorides and Human Health* (Geneva, 1970), 274–87. Waterworks served 94 million Americans in 1945 and 160 million in 1965. Melosi, *The Sanitary City* (cit. n. 8), 298.

such as Colorado Springs that their sparkling tap water was to blame.[11] From the start, American efforts to link fluoridated water with disease confronted fluoride's imperceptibility to lay water drinkers, along with the acquired reputation of piped water as "sanitary."

The broader backdrop for this move was what I have described elsewhere as an environmental turn in the American health science community. Especially over the 1920s and '30s, health scientists applied the methods of analytical chemistry ever more ambitiously and rigorously to the "natural" and environmental exposure levels of substances known or suspected to cause human ills. Investigators of mottled enamel followed lead poisoning researchers in undertaking some of the most extensive of these early initiatives. Yet despite detailed scrutiny of its geographic variations that increasingly focused on a drinking water link, fluoride only emerged as a causal candidate in 1929. Unlike lead scientists, who focused mainly on that toxin's occupational origins, investigators of the link between fluoride and mottling built on the assumptions of this earlier epidemiology that "natural" groundwater, rather than industry, was to blame. Indeed, the corporate ties of this new U.S. environmental health science, in an era before extensive federal funding of health research, helped steer laboratory confirmation of the link between fluoridated water and mottling. Henry Churchill, who produced the first analytical evidence for the connection between Brown Stain and the fluoride content of faucets, was the chief chemist of ALCOA, the Aluminum Corporation of America. Driving chemist Churchill's investigation were his concerns that the stained teeth of inhabitants of Bauxite, Arkansas, an ALCOA town, would feed consumer fears about the health dangers of aluminum cooking ware. As with Robert Kehoe's demonstrations that measurable lead levels in many Americans were natural and normal, Churchill's proof that fluoride was the culprit for the browning of Bauxite children's teeth quieted people's fears about industry.[12]

Beyond quantifying fluoride's ties to mottling, what secured the uniqueness of the American science of fluoridated water during this era was its establishment of benefits. During the 1930s, investigators at the Public Health Service (PHS), led by H. Trendley Dean, established elevated "natural" levels of fluoride as a cause not just of mottling but also of reduced rates of cavities. Trendley Dean and other PHS investigators first set out to study mottling across larger populations and a wider geography, then focused on determining what fluoride levels could suppress cavities without mottling children's teeth. Dean acknowledged strong evidence that other environmental factors outside of water were likely contributors to cavities—diet ("of major importance") and possibly latitude and sunlight intensity. To bring out just how influential water was, however, he and his colleagues designed studies in which these other factors remained relatively constant. The "magnitude of the sample" presumably washed out any dietary contributions among communities whose proximity equalized other

[11] J. M. Eager, "Denti di Chiaie (Chiae Teeth)," *Public Health Reports* 16 (1901): 2576; among McKay's studies, see Grover Kempf and Frederick McKay, "Mottled Enamel in a Segregated Population," *Public Health Reports* 45 (1930): 2923–40; McNeil, *Fight for Fluoridation* (cit. n. 1), especially 19–21.

[12] H. V. Churchill to F. S. McKay, 15 Nov. 1931, McKay papers, as cited in McNeil, *Fight for Fluoridation* (cit. n. 1), 27 n. 40; Christopher Sellers, *Hazards of the Job: From Industrial Disease to Environmental Health Science* (Chapel Hill, N. C., 1997); Kaj Roholm, "Fog Disaster in Meuse Valley, 1930: Fluorine Intoxication," *Journal of Industrial Hygiene and Toxicology* 19 (March 1937): 126–37.

climatological and geographic factors.[13] No clear line emerged to denote where mottling ceased and cavities began. One part per million of fluoride showed a definite decrease in cavities but linked with the mildest form of mottling in 10 percent of the population—a percentage that rose gradually with fluoride levels of more than 1 ppm. Given the possible benefits, public health officials in the 1940s decided to intervene on an experimental basis using a prospective epidemiological design, a design that smoking studies would, in the following decade, make the gold standard of epidemiological practice. They chose two communities with low natural levels of fluoride in the water—Grand Rapids, Michigan, and Newburgh, New York—and in early 1945 began adding one part per million of this chemical to the towns' water supplies.[14] The dose-response curves constructed by PHS epidemiologists under Trendley Dean made them confident that with between 0.7 and 1.5 ppm of fluoride in the water, cavity reduction could be bought with minimal mottling.[15]

"Inoculating" an entire community's water supply with fluoride meant transporting benefits enjoyed by some western children to the cavity-prone majority in the East. The decision came at a meeting in Washington, D.C., within the Epidemiology Branch of the National Institute of Dental Research, on November 11, 1942. The PHS's Stream Pollution Division had just declared the idea technically and economically feasible. Nevertheless, uncertainties and worries plagued early PHS advocates of this initiative even as they pressed forward.

They anticipated that fluoridated water was going to be a hard sell with nonscientists. One doctor commented that "the psychology of introducing fluorine into the water supply unless handled properly, might produce condemnation of the procedure on the part of the public." Beyond psychology, they fretted about the physiology: What might happen "when minute amounts of fluorine are ingested over a long period of time"? What were the "possible undesirable effects on the human system not yet detected"? By no means "essential," fluoride, then known as a pesticide component and an air pollution culprit, was "universally recognized as a toxic element." Noting that tolerance levels had been set for fluoride insecticide residues, also that "human error" could somehow result in " high proportions of fluorine (e.g., 1,000 parts per million)," conferees pointed out that "several foreign studies (inadequately controlled) [reported] that osteosclerosis or other bone changes are found in people that had used fluorine water." PHS doctors had taken such reports seriously enough to launch a "small study (ten cases)" of their own, which failed to support these "foreign" findings.[16] American health experts were not convinced that fluoride intoxication from water was possible.

At the 1942 PHS meeting in Washington, there was little discussion of fluoride exposures outside drinking water. The lofty epistemological standards attained by Dean wrought a convincing environmental reductionism: the dose-response relationship he

[13] See, e.g., H. Trendley Dean, Philip Jay, Francis Arnold et al., "Domestic Water and Dental Caries, Including Certain Epidemiological Aspects of Oral L. Acidopholus," *Public Health Reports* 54 (1939): 862–8, as reprinted in F. J. McClure, ed., *Fluoride Drinking Waters* (Bethesda, Md., 1962), 90–101, on 90.

[14] McNeil, *Fight for Fluoridation* (cit. n. 1), 3–43.

[15] H. Trendley Dean, "Domestic Water and Dental Caries," *Journal of the American Water Works Association* 35 (Sept. 1943): 1168–9.

[16] Dr. W. J. Pelton to Dr. J. W. Mountin, "Report of Conference held on November 6, 1942, in the Bureau, regarding public health aspects of fluorine inoculation in public water supplies," Folder "Fluoridation Memo 1942," Box 1, Fluoride Papers (cit. n. 2).

had abstracted between water levels and cavities became the sole consideration. The stability of this reduction was still vulnerable; PHS officials did resolve to undertake a further, more comprehensive investigation of what happened to adults who drank "fluorine water" over a period of "many years." However, their collective eagerness to test the fluoride remedy itself remained virtually undeterred. The sole nonmedical or -dental participant at these hearings, a sanitary engineer by the name of Hoskins, voiced the greatest skepticism.[17] The group consensus was that this study of long-term exposure could accompany, rather than precede, the fluoridation of an entire community's water supply. After all, whatever the "foreign" claims, in America "populations undoubtedly move from high fluorine areas to low fluorine areas and vice versa, without any noticeable or reported undesirable effects."[18]

The PHS dismissed reports of skeletal fluorosis elsewhere, and in the United States the naturally fluoridated water found in a few parts was soon transmogrified into a new, population-wide standard for water—and dental—normality. Increasingly over the previous couple of decades, chlorine as well as water softeners had been added to urban Americans' drinking water, so public health officials themselves saw nothing unprecedented in this proposal. Now also penetrating into midsize and smaller cities, chlorination had given rise to scattered complaints about the aftertaste but no vocal or organized resistance.[19] Fluoride might even stir up even fewer problems, being both tasteless and odorless. Fluoride's American investigators soon shifted their sights to the unfluoridated parts of their nation. By the late forties and early fifties, investigators found the diminishing tooth decay in their two experimental communities (32.5 percent less in Newburgh by 1951 and as much as 43 percent less in Grand Rapids) rapidly approached that in naturally fluoridated communities (nearly 60 percent lower), unaccompanied by more dire disease. PHS investigators had initially envisioned the Newburgh and Grand Rapids studies as modest "experiments" that would last ten to fifteen years, but eager dentists began to make the case that nearly every community should consider fluoridating their water, across the United States and the world.

Over this same period, PHS efforts to *de*fluoridate drinking water also got underway in the relatively few western American towns with naturally high fluoridation levels, but these efforts remained vastly overshadowed in the United States by the scientific scrutiny and promotion of fluoridation.[20] Meanwhile, the authors of those foreign studies that PHS scientists dismissed as "uncontrolled" and unconfirmed, Indian public health scientists, had developed different priorities.

THE INDIAN SCIENCE OF FLUORIDATED WATERS: ARTIFICE OF THE NATURAL

As in the United States, much groundwater used for drinking in India had negligible fluoride content. But larger slices of the Indian subcontinent had elevated (greater than 1ppm) fluoride waters, including long and densely settled rural areas. In places

[17] E. Hunt, "Water and Turf: Fluoridation and the 20th-Century Fate of Waterworks Engineers," *American Journal of Public Health* 87 (1987): 1235–6.

[18] Pelton, "Report of Conference held on November 6, 1942" (cit. n. 16).

[19] Only about one-third of American waterworks had chlorinated their water by 1939. Melosi, *The Sanitary City* (cit. n. 8), 223–4.

[20] F. J. Maier, "Defluoridation of Municipal Water Supplies," *Journal of the American Waterworks Association* 45 (1953): 879–88.

the content could reach much higher than that in any American drinking water supply, upward of 70 ppm. Importantly, these differences in concentration, reported in the first WHO bulletin on fluoride and health in 1970, reflected more than regional contrasts in groundwater sources. They also involved differences in the technology of water supply. Whereas the Americans measured fluoride levels along water pipes even in the smaller towns, their Indian counterparts, when outside the largest cities, analyzed water from springs, "spring pits dug out of the bed of streams," and hand-dug village wells. Such water was often laced not just with dissolved fluoride but also with fluoride-containing sediments—the kind of particles screened out of most "sanitary" waterworks in the United States by this time.[21] Indian health scientists and officials, however, not only faced intensive levels of fluoride exposure but also had to deal with problems in measuring the many sources of village drinking water.

Underdeveloped as India's water supply was, Indian health scientists themselves kept in touch with the new methods and trends in Western medical science. As in the West, their health science undertook an environmental turn: analyses of fluoride in drinking water began only slightly later on the Indian subcontinent than in America. During the mid-1930s, Indian scientists' studies of fluoride began like those of their American counterparts with a mysterious ailment, reported by health inspectors as well as a doctor from the Baptist mission in the Nellore District of southern India. The ailment was as localized as mottled enamel but far more severe. Its adult victims experienced a crippling of the bones and joints that, at its worst, rendered them immobile. The local villagers attributed the problem to drinking water. One of the first steps taken by early investigators—one not taken by their American counterparts looking into mottling—was to bring some of the victims into a hospital, the King Institute of Preventive Medicine in Guindy, near Madras. In 1936, institute researcher C. G. Pandit, "in the ordinary course of reading" European medical journals, ran across a report of similar skeletal disease found among workers in a Danish cryolite factory, identified as "chronic fluorine poisoning." Remembering Nellore's fluoride-rich mica mines, Pandit and his colleagues proceeded to investigate fluoride levels in local well water and the parallel occurrence of mottled enamel asserted in American publications. The syndrome of "skeletal fluorosis" that the Indian investigators went on to define had been unknown among Indian diseases as well as those found in the international medical literature. With the new fluoride pathology came an additional mystery. The water fluoride levels first measured in India were surprisingly close to those measured in America where mottling, but no more severe disease, had been identified.[22]

Stabilizing as a disease, skeletal fluorosis quite suddenly acquired an intense yet puzzling reality for these scientists and physicians in Guindy. They did use experi-

[21] Institute of Social Sciences, *Fluorosis in India* (cit. n. 2); WHO, *Fluorides and Human Health* (cit. n. 10), 17ff.; C. G. Pandit, T. N. S. Raghavachari, D. Subba Rao et al., "Endemic Fluorosis in South India: A Study of the Factors Involved . . . ," *Indian Journal of Medical Research* 28 (1940): 540. On Indian water systems, see Anil Agarwal and Sunita Narain, "Dying Wisdom: The Decline and Revival of Traditional Water Harvesting Systems in India," *The Ecologist* 27 (1997): 112ff.

[22] H. E. Shortt and C. G. Pandit, "Endemic Fluorosis in the Nellore District of South India," *Indian Medical Gazette* 72 (1937): 396–8, on 396; Rao Sahib, T. N. S. Raghavachari, and K. Venkataramanan, "The Occurrence of Fluorides in Drinking Water-Supplies with a Note on Their Removal," *Indian Journal of Medical Research* 28 (Oct. 1940): 517–32; Pandit et al., "Endemic Fluorosis in South India" (cit. n. 21). On the larger Indian medical context, see Mark Harrison, *Public Health in British India: Anglo-Indian Preventive Medicine, 1859–1914* (Cambridge, 1994); Roger Jeffrey, *The Politics of Health in India* (Berkeley, Calif., 1988).

mental controls, but only to test the contribution of vitamin C to the presumed intoxication in monkeys. They were convinced that fluoride was the culprit because of their patients' resemblance to the Dutch cryolite workers as well as the ubiquity and severity of the ailment around highly fluoridated wells. Some 74 percent of those examined in high-exposure areas showed some "bone affections"; 14 percent, mostly long-term residents, showed the severest form, "a complete rigidity of the spine . . . immobility of the joints of both extremities, [and] the fixation of the thoracic wall so that breathing became entirely abdominal." While U.S. PHS researchers dismissed early reports from India, the Indian researchers struggled to reconcile their findings with those of the Americans. Initially, they surmised that ailing, elderly Indian villagers in their hospital had simply been exposed much longer than any American counterparts, periods of forty years or more. When field surveys of implicated villages showed how widespread the syndrome was among the middle-aged as well as the elderly, investigators were forced into a multifactorial approach, with a much less stable focus on water than that of their American counterparts. They looked into the fluoride and other content of local diets and soil, into vitamin intake, nutrition, and even economics.[23]

Those who first defined skeletal fluorosis in India also turned to reconstructing its local past. Unlike either McKay or Latour's Pasteur, they began with a sweeping and unvarying "retrofit" of this disease on to the local past and only subsequently turned more historicist.[24] The clinicians who saw the first victims in a Guindy hospital in 1936 reasoned broadly that the disease, "since it comes in the first instance from the soil, might truly be described as being in this area as 'old as the hills.'"[25] But as other researchers visited the stricken villages to gather information, and the discrepancies with American and other studies became clear, these extrapolations quickly gave way to more limited and nuanced surmises about the disease's past. By 1940, investigators had realized how recent changes in the water supply might have contributed to the ailment's scope, even as they had gained a new appreciation of the prescientific, "quotidian" knowledge about it.

Prior to the official medical discovery of this disease, the connection between bone ailments and drinking water had become so persuasive and intense to many rural Indians that when stricken, entire villages moved, in search of less contaminated water sources. Though they also attributed other ailments to the water and faulted the micaceous rocks of the region rather than an invisible fluoride, the villagers' empirical choice of one source of water over another often correlated with a lower fluoride content, investigators were surprised to discover. The scientists' own chemical knowledge was challenged since fluoride was supposed to be imperceptible to the human senses. The investigators soon established why the villagers' quotidian surmises often proved reliable: high fluorine content correlated with "high total solids," what the villagers could see.[26] Moreover, Indian villages by the 1930s were seeking water in new ways, departing from traditional water-harvest methods partly in response to warnings

[23] Sahib, Raghavachari, and Venkataramanan, "Occurrence of Fluorides in Drinking Water-Supplies" (cit. n. 22); Pandit et al., "Endemic Fluorosis in South India" (cit. n. 21), 538; see also H. E. Shortt, G. R. McRobert, T. W. Barnard et al., "Endemic Fluorosis in Madras Presidency," *Indian Journal of Medical Research* 25 (Oct. 1937): 553–68.

[24] Latour, *Pandora's Hope* (cit. n. 6), 168–71.

[25] Shortt et al., "Endemic Fluorosis in the Madras Presidency" (cit. n. 23), 554.

[26] Shortt and Pandit, "Endemic Fluorosis in the Nellore District," 397; Sahib, Raghavachari, and Venkataramanan, "Occurrence of Fluorides in Drinking Water-Supplies," 521. (Both cit. n. 22.)

about the infectious dangers of surface waters. In areas of Nellore hardest hit by skeletal fluorosis, high fluoride was found both in springs and in wells of 15–30 feet, "in actual daily use for several years." But in other districts, the fluoride content of wells 50–200 feet deep, dug since 1938, turned out to be considerably higher than in surface sources. With the new recognition of fluoride's risks, Indian villagers and public health officials found themselves on the horns of a dilemma: deeper wells considered "safe from the sanitary point of view" poured forth new, risky levels of fluoride.[27]

Indian investigators establishing this disease as a medical entity continued to think of it as long-standing and endemic to Nellore but came to realize additional complexities to its history—the way in which it had been influenced by changing water supply as well as the villagers themselves. From the outset, Indian public health scientists and officials also considered defluoridation but operated in a far different technological and sociopolitical context than their American counterparts. While Indian public health was not shaped as much by corporate interests, it was also not as well endowed; in addition, it remained overwhelmingly oriented toward infectious disease. Even "sanitary" measures well established in western American towns—chlorination as well as filtered and piped water—remained forestalled in the Indian countryside where fluorosis had been found. Nevertheless, as more Indian investigators looked for this chemically defined disease, its estimated distribution grew, along with the population at risk. By the early 1950s, middle-age adults and children had been found to have skeletal fluorosis, in northern as well as southern India, sometimes from levels of water exposure as low as 1–2 ppm. Though India's first defluoridation plant went online in 1961, for most afflicted regions the only feasible solution was what McKay prescribed in the 1920s for overfluoridated American towns: switching water supplies.[28] As Indian public health fitfully grappled with the subcontinent's excess of fluoride, in other parts of the world, the fluoridation campaign itself gained momentum.

THE INTERNATIONAL SPREAD OF FLUORIDATION AND SKELETAL FLUOROSIS

Beyond India, especially in other Western countries, the introduction of fluoride into drinking water confirmed the uniformity of fluoride's effects on tooth decay in children, at least across the major English-speaking nations.[29] In Canada and in Britain, campaigns for fluoridation got underway during the 1950s. International agencies also launched single-city fluoridation projects in the third world. By 1963, fluoridation advocates at the Fédération Dentaire Internationale (FDI) could boast that water fluoridation plants were in operation or "will start in the near future in 41 countries." Yet nowhere had fluoridation caught on to the extent it had in the United States. While 46 million Americans drank fluoridated water, fewer than 4 million Canadians did;

[27] Sahib, Raghavachari, and Venkataramanan, "Occurrence of Fluorides in Drinking Water-Supplies" (cit. n. 22), 518. More generally, see Agarwal and Narain, "Dying Wisdom" (cit. n. 21).

[28] A. H. Siddiqui, "Fluorosis in Nalgonda District, Hyderabad-Deccan," *British Medical Journal* 2 (10 Dec. 1955): 1408–13; P. Venkateswarlu, D. Narayana Rao, and K. Ranganatha Rao, "Studies in Endemic Fluorosis: Visakhapatnam and Suburban Areas," *Indian Journal of Medical Research* 40 (1952): 535–47; Amarjit Singh, S. S. Jolly, B. C. Bansal et al., "Endemic Fluorosis: Epidemiological, Clinical, and Biochemical Study of Chronic Fluorine Intoxication in Panjab (India)," *Medicine* 42 (1963): 229–46.

[29] Subcommittee on Fluorine, *Fluorine Benefits and Risks* (cit. n. 2), 26.

next in line were Colombia, Chile, and Hong Kong. Striking exceptions appeared in Europe, where only 100,000 people in Britain and none in Germany had water artificially fluoridated.[30]

Around this same time, international controversy over just what the fluoride content of water should be led to a FDI appeal to the World Health Organization to compile "an authoritative and up-to-date report on the metabolism of fluorine." Though spurred by fluoridation advocates, the resulting 1970 publication, *Fluorides and Human Health,* nevertheless aspired to an "impartial review of the scientific literature" that had accumulated across the globe. Heavily reliant on, even dominated by, U.S.-based scientists, the publication became an international showcase for Indian researchers as well. Two Punjabi scientists, S. S. Jolly and A. Singh, wrote most of the section on "Toxic Effects of Larger Doses of Fluoride."[31] An official expression of the global ambitions of fluoridation investigators, the report also confirmed the arrival of waterborne skeletal fluorosis as a stable, recognized reality for scientific and medical elites in other parts of the world, including America itself.

Reconciliation between American and Indian depictions of fluoridated water came in part through working hypotheses by Indian researchers about what gave fluoridated water in the United States a less pathological punch: lower temperatures, ingestion of smaller quantities of water and better nutritional conditions, along with the lack of undissolved sediments in American water, and the lesser physical strain involved in most Americans' work. U.S.-based researchers, for their part, conceded that even in America, "optimal" levels of water fluoride might vary by temperature. Important as well were the ways fluoride researchers in both India and America responded to a traveling network of antifluoridationists, including doctors such as George Walbott. Walbott, who began spreading word about the Indian findings in the United States in the 1950s, claimed to have found skeletal fluorosis in his American patients.[32] To refute such claims, American researchers investigated U.S. communities exposed to high-fluoride drinking water and found little hint of skeletal fluorosis, while Indian medical scientists, sealing their credibility with the Americans, questioned whether the fluoride pathology claimed by Walbott was the same as that seen in highly fluoridated Indian patients. "The evidence from the clinical studies of fluorosis with regard to systemic intoxication," wrote Singh and Jolly, "is mostly of a negative nature, with the exception of dental, skeletal and neurological effects."[33]

Questions still hovered about just why Indian villagers seemed so much more vulnerable to fluoridated water than their American counterparts. But by weaving both national versions of fluoride health science into the same official WHO publication, Indian and American health elites crafted a new level of international stability for fluoridated water and its effects. Simultaneously, they joined forces against those people whose apparent impact most irked fluoridation advocates. While poverty, technical obstacles, and the continuing dangers of infectious disease understandably

[30] Leatherman and Ellis, "Fluoridation round the World," 27; Subcommittee on Fluorine, *Fluorine Benefits and Risks,* 22. (Both cit. n. 2.)

[31] WHO, *Fluorides and Human Health* (cit. n. 10), 11. A majority of the authors held American posts.

[32] George Walbott, with Albert W. Burgstahler and H. Lewis McKinney, *Fluoridation: The Great Dilemma* (Lawrence, Kans., 1978), 106.

[33] WHO, *Fluorides and Human Health* (cit. n. 10), 274–84, 287, on 263.

diverted the rest of the world from fluoride's virtues, what truly dumbfounded America's fluoridation experts was the public opposition that sprouted in their own backyards.

AGAINST FLUORIDE IN AMERICA: WATER NATURALISM ON A LANDSCAPE IN FLUX

In the Stanley Kubrick film *Dr. Strangelove,* General Jack T. Ripper obsessed about the "communist" threat of fluoride to his "precious bodily fluids." If Kubrick crystallized the link in American popular culture between antifluoridation and cold war paranoia, many social scientists of the time looked to American society itself for explanations of the movement's "antiscientific" attitudes. Drawing on national statistical aggregates that showed antifluoridationism most rife among the uneducated and lower classes, researchers attributed those attitudes to a feeling of "loss of personal control" in a world of large and complex organizations caused by "relative deprivation" or viewed the attitudes as a "political protest by the powerless." The social scientists often emphasized the effectiveness of traveling antifluoridationists in getting their message across to lay audiences. This group of antifluoridationists comprised some individuals with medical or other expert credentials such as George Walbott and Howard Spira, though their numbers were inveterately cast as "small" by social scientists.[34] In investigating antifluoridationism, however, those scientists did not ask many questions about the ontology of water, disease, and health that led lay majorities to turn down fluoridation referenda in so many cities and towns, and the local and personal histories in which that ontology was grounded.

While in India some of the laypeople's ontology of fluoridated water comes through the investigators' reports of fluoride, in America, it is the public debates over fluoride referenda that offer a revealing window into the perceptions of the antifluoridationist laity. On May 9, 1958, the Manhasset-Lakeville water district in Nassau County, N.Y., rejected fluoridation by a whopping four-to-one margin. Manhasset-Lakeville defied social scientific generalizations about antifluoridation as lower class; an older, wealthier slice of Long Island, it had the highest assessed property valuation of any Nassau County water district. Unlike with health scientists in India, no particular ailment dominated the perception of fluoridated water among its many Manhasset opponents. Local antifluoridationist sentiment in this, as other areas, hinged on what the contemporary political scientist Morris Davis somewhat derisively termed "a *drive toward naturalism* or a *naturalist syndrome.*"[35] The "natural" served a purpose comparable to scientists' "retrofits"; it traced backward what, in this case, local memories confirmed as solid and real, what laypeople felt they knew about "quotidian" substances such as food and water and their health impacts. Constituting a modern version of Hippocratic ontology (oriented toward *Airs, Waters, and Places*), Manhassetites deemed familiar substances and practices natural, even if only recently (and by

[34] A. Green, "Ideology of Anti-Fluoridation Leaders," *Journal of Social Issues* 17 (1961), 13–25, on 16; W. Gamsom, "The Fluoridation Dialogue: Is It an Ideological Conflict?" *Public Opinion Quarterly* 25 (1961): 526–37; Arnold Simmel, "A Signpost for Research on Fluoridation Conflicts: The Concept of Relative Deprivation," *Journal of Social Issues* 17 (1961): 26–44; Benjamin Paul, "Fluoridation and the Social Scientist," ibid., 9.

[35] Morris Davis, "Community Attitudes toward Fluoridation," *Public Opinion Quarterly* 23 (1959): 478.

their own admissions) contrived. Lay antifluoridationism in the Manhasset-Lakeville district asserted what was "natural" not just in reaction to the fluoridation campaign, but also to longer-standing local developments that traveling advocates, pro and con, rarely addressed, from groundwater pollution to fundraising for disease research.

As with Indian villagers, Manhasset-Lakeville residents' contentions about fluoride were tightly bound to the history of their water supply. Since before the district's first waterworks, in 1910, drinking water had come from underground aquifers. These absorbed a rising influx of human waste as Nassau County suburbanized. Beginning in the 1930s, public health officials began warning residents of Manhasset-Lakeville about threats of groundwater contamination and depletion. In the following decade, nitrates began to appear in the upper layers of the aquifer. During and, especially, after World War II, new influxes of people into Nassau County—a 65.4 percent population gain between 1940 and 1950 and a 93.3 percent gain in the succeeding decade—placed additional strains on the county's underground water supply, strains only partly alleviated by the opening of a county sewage plant in 1949. The biggest problem continued to be the septic tanks and cesspools on which more than half of Nassau County homes relied, which leached wastewater into the local earth. Manhassetites' attunement to "chemical tastes" and pollutants in their water pushed officials there and in neighboring districts to dig deeper, so that chlorination was only intermittently necessary. Wells delved downward as far as 780 feet by the early 1960s, ensuring an official "natural purity" to the drinking water.[36]

Throughout the fifties, discussions of waterborne as well as other environmental threats from rapid postwar growth often sidestepped any mention of pathology or toxin through a less medicalized language of "contaminants," "stink," and "pollution." When disease terminology did surge into local headlines it was because of lay groups targeting single, specific diseases. In Manhasset as elsewhere in postwar America, local chapters of the American Cancer Society, the Cerebral Palsy Auxiliary, and the March of Dimes (against polio) emerged as prominent forms of civic engagement. Mostly centered around pathologies for which there were as yet no antibiotic or other decisive cures, these organizations reflected a long-term shift in the United States from infectious to chronic diseases (with the exception of polio) as major causes of mortality and predominant targets of medical concern. Unlike that of the Western age of infection, as well as that of contemporary India, the "preventive" component of midcentury American disease agitation was much more confined: report any suspicious symptoms to one's doctor. In stark contrast to today's breast cancer movement, the groups were silent about whether laypeople themselves could do anything to avoid these diseases; the unifying purpose of these organizations was to raise funds for research in distant medical centers and laboratories. Though the *raison d'être* for these disease groups appears to have been the cultivation of medical trust, they inadvertently brought home just how little doctors knew about these ailments.

The push for fluoride in Manhasset-Lakeville, preventive in orientation, also fix-

[36] Dick Wetterau, "Editorial Musings," *Manhasset Press,* 3 April 3 1958; "County Board of Supervisors Gets Sewer Report . . . ," *Manhasset Press,* 3 Jan. 1936; Department of Rural Sociology, Cornell University Agricultural Experiment Station, "The People of Nassau County, New York, 1900–1960," *Bulletin* no. 62–28 (Aug. 1963): 2; Nassau-Suffolk Regional Planning Board, *Utilities Inventory and Analysis* (1969), 23; Manhasset-Lakeville Water and Fire Districts, (1963?) typed manuscript Folder "L. I.–Water Supply," Manhasset Public Library, Manhasset, N.Y.

ated on a single disease and on expert control. District officials seized upon the idea sometime in 1957. Keenly aware of the controversy fluoridation had aroused elsewhere, they agreed to a local referendum, the first on Long Island. The ensuing public debate penetrated into the local social fabric through town newspapers as well as meetings of several civic associations. In contrast to a successful petition drive by a newspaper editor and other advocates in Levittown, another Nassau County community, these public presentations were structured as debates rather than expert "education." Spokespeople for the opposition, given time and opportunity comparable to those of fluoridation advocates, shattered the insistent focus of the latter on alleviating cavities.[37]

Local advocates in Manhasset included a dentist and presidents of the county medical and dental societies. Unlike their opponents, they did not write letters to the local papers; in debates, they probably presented arguments similar to those of Levittown's fluoride promoters. In Levittown, dental effects were depicted as contributing to overall healthiness—and savings. "If you have a child under 12 years of age, as most Levittowners do, there is something that can be done which will make him healthier, improve his appearance, add to his happiness—and save you hundreds of dollars in dental bills." Endorsement by "many dental societies" and other professional groups was critical. Quotes from local dentists were paraded alongside assertions of proven benefits, shown by "tests that were conducted over periods of years under the supervision of government, state and local health authorities, and official dental organizations." Advocates admitted that fluoride was a "poison" but insisted there were no "adverse effects" at the levels being proposed. Crucial to their case was their account of "natural" fluoride. Discovery of fluoride's beneficial effects came through study of natural levels that were too high in some places, causing mottling, and hence, also in need of adjustment. As many a science studies scholar has recognized, this kind of argument naturalized experts' politics alongside many of their reductions and results; claims about the "nature" of water served as arguments for an expert-controlled "normalizing" of water supplies.[38]

Fluoride's lay opponents rarely questioned whether fluoride was effective against tooth decay. They emphasized what else it did and, especially, *might do*—the shadowy possibilities of harm that PHS scientists by this time considered their own studies to have mostly dismissed. "In addition there is a host of other possible disorders such as gastrointestinal disturbances, spotty baldnes [sic], eczema, cardiac and respiratory disorders, etc. that may be traced to fluoride ingestion." For the Manhasset Pure Water Committee, fluoride was a "cumulative poison . . . involved in a great number of diseases such as arthritis, heart [and] kidney disease, diabetes and allergic disorders." The multiple pathologies invoked here were far more dire than tooth decay, yet they were also more tenuous and fleeting than that found in the traveling antifluoridationists' literature. Only disease names appeared; allusion to skeletal fluorosis was confined to fluoride-related "bone

[37] See, e.g., "Lake Success Debates Fluoridation," *Manhasset Press,* 27 March 1958; see also Sheila Jasanoff, "Science, Politics, and the Renegotiation of Expertise at EPA," *Osiris* 7 (1992): 195–217.

[38] "Fluorine in Our Water? Local Dentists Favor Plan," *Levittown Tribune,* 26 July 1951; "Fluorine in Our Water? It's Safe and Tasteless," *Levittown Tribune,* 9 Aug. 1951; Sidney Sussman, "Think Then Vote," *Manhasset Press,* 31 April 1958; Sheldon Levinson, "Approves Fluoridation," *Manhasset Press,* 8 May 1958.

changes" mentioned in a single letter. This disease had only the wispiest reality for Manhasset's fluoride opponents.[39]

Fluoride itself sounded disturbingly evasive to its opponents, especially in comparison with the more familiar chlorine. Most troubling, fluoride offered ordinary water drinkers fewer clues about when it reached excessive amounts. While high chlorine levels gave rise to an "irritant reaction on the eyes and nose," fluoride's odorlessness and tastelessness made it "not as easily discoverable except by qualitative and quantitative tests," that is, tests by experts.[40] In contrast to adding chlorine to water, and the natural presence of fluoride in the water of far-off Nellore, putting fluoride into faucets would erode laypeoples' ability to taste the risks in their drinking water. The Manhasset Pure Water Committee, broaching local anxieties about sewer seepage into groundwater, placed chlorine itself squarely on the side of water purity: "Sure, chlorine in the water to kill germs is necessary . . . pasteurization of food to kill germs is necessary . . . BUT FLUORIDE FOR MEDICAL PURPOSES IS ANOTHER STORY. . . . ***It is mass medication for a non-communicable disease.***"[41] Forthright about their water's historical and human shaping, they readily admitted established and continuing public health measures against infectious diseases within the scope of their "natural," while attacking the unnaturalness of fluoridation.

Repeated accusations of "mass medication" exemplify how lay antifluoridationists slid from water ontology to explicit sociopolitical critique far more readily than fluoridation's advocates. The phrase echoed a widespread targeting of "mass society" in the national media, which took fluoridated Levittown as its suburban exemplar. Antifluoridationists indicted what they saw as an overstepping of proper jurisdictional boundaries between medical and lay decision-making. "Fluoridation is *not a medical problem,*" stated the Manhasset Pure Water Committee. "It is simply a question of whether or not we want our water supply used for medication." Conceding that there were "scientific" and "medical" realms in which experts rather than laypeople were most competent to know and decide, many antifluoridationists were perfectly willing to accept fluoride through traditional clinical channels (e.g., medical prescription of fluoride tablets). As Mrs. George Conway argued, however, there were "many other aspects to this question [of fluoridation] besides the scientific aspects which were within the competence of lay persons to evaluate."[42] For her, it was the fluoridation scientists who were transgressing established boundaries by asserting that all or most aspects of water supply should be left to experts. Still worse was the precedent it would set for the local civics of specific diseases. The public water system would become a "happy hunting grounds for every group with a pet illness to cure."[43]

Antifluoridation talk was full of critical commentary about science and scientists: how in this case "professional opinion" seemed "divided," how arrogant and "brazen"

[39] Letters to the editor: Dinah Dever, "Twenty Years Ago . . . ," *Manhasset Press,* 27 March 1958; Mrs. George Conway, "Hits Fluoridation," *Manhasset Press,* 24 April 1958; Cecilia Schwartz, "Fluoridation Question," *Manhasset Press,* 17 April 1958; Dinah Dever, "Fluoridation Facts," *Manhasset Press* 8 May 1958 ("bone changes").

[40] Schwartz, "Fluoridation Question" (cit. n. 39).

[41] Manhasset-Lakeville Pure Water Committee, "Let's Really Protect Our Children's Teeth," *Manhasset Mail,* 1 May 1958.

[42] Ibid.; Conway, "Hits Fluoridation" (cit. n. 39).

[43] Pure Water Committee, "Protect Our Children's Teeth" (cit. n. 41); Schwartz, "Fluoridation Question" (cit. n. 39).

the scientific advocates of fluoride seemed.[44] But it was through appeal to their own memories—as a Mrs. Tangredi put it, "the practical, down to earth experience of a person who is unbiased"—that lay antifluoridationists reached to the heart of skepticism about fluoride. Al Fisher noted how "my wife and four children have gotten along very well without the magic chemical."[45] In claiming their own ability to recognize what was best when it came to fluoridated water, many were inclined to emphasize homebound ways of contending with cavities that they had long known and practiced. According to the Manhasset Pure Water Committee, prevention was "a matter of proper diet, dental care, cleanliness and heredity," mostly the mother's realm. The committee, "composed largely of mothers," saw fluoridation as a medical and governmental imposition on the private home, domesticity, and for Conway, women's prerogatives. "Should we not conceivably expect that the time will come when our government will supervise our children's meals and the hours at which we put them to bed?"[46]

A crucial step in many antifluoridationists' arguments was casting the assault on this naturally domestic and private realm as a threat to democracy: "[a] violation of the democratic right of every individual to drink what he wants and to take the medicine he needs." The rights fluoridation failed to respect were, quite literally, consumers' rights and, by extension, rights to bodily control. As Conway eloquently summed it up, "Let us at least retain the mastery of our own bodies if by so doing we improve or injure no one but ourselves!"[47] The political ideology of Conway and others, which inclined them to accuse fluoridationists of "socialism," seemed to confirm an imagined alliance of antifluoridationists to a global struggle against communism. Yet the wider embrace of antistatist arguments about body mastery, beyond a McCarthyesque right, suggests that in 1950s Nassau County, shared local history and experiences were at least as important. A few miles from Manhasset, Marjorie Spock schemed unsuccessfully to convince her brother Benjamin, the renowned pediatrician, to speak out against fluoridation and organized a lawsuit against a state-run DDT spray campaign. This first public trial against DDT provided evidentiary bases for Rachel Carson, then commencing research for what would become the book *Silent Spring*.[48] Not just the Goldwater right but postwar environmentalists owed important debts to the antifluoridation campaigns.

In view of this legacy, it is striking how, without any Carsonian appeal to ecology, Manhasset's antifluoridationists worried about environmental ramifications of fluoridation that ranged beyond the faucets on which its advocates fixated. Leery of the stable, tidy formulae of fluoridation science, opponents imagined fluoride flows and accumulations, especially in and around their home turfs, about which fluoride's advocates had little to say. The Manhasset Pure Water Committee noted how "fluoride becomes more concentrated when boiled or used for cooking . . . to add to the hazard." For Clara Harban, the prospect of widespread fluoridation conjured up a vision of innumerable other pathways by which this "cumulative poison" might undermine even the best intentions for a "wholesome" diet. "Can you imagine if the entire coun-

[44] Conway, "Hits Fluoridation" (cit. n. 39); Mrs. S. Tangredi, letter to editor, *Manhasset Mail,* 1 May 1958.

[45] Tangredi (cit. n. 44); Al Fisher, "Dear Editor," *Levittown Eagle,* 14 Feb. 1952.

[46] Conway, "Hits Fluoridation" (cit. n. 39).

[47] Ibid.

[48] Christopher Sellers, "Body, Place, and the State: The Makings of an 'Environmentalist' Imaginary in the Post–WWII U.S.," *Radical History Review* 74 (winter 1999): 31–64.

try becomes fluoridated there won't be a canned or frozen fruit, vegetable or soft drink that won't have fluorides in them. So again, how do you control the dose?"[49] Just as the Indian investigators of fluorosis looked to diet to help explain effects for which fluoridated water alone seemed insufficient, so antifluoridationists fretted that fluoridated water would spill over into dietary flows.

The practices that antifluoridationists defended as natural were time-tested, but far from eternal: how medical and dental clinics administered their medicine, how chlorine's bitter taste clued people in to elevated water levels, how dietetic and hygienic supervision could allay cavities in children's teeth. Touting the "naturalness" of these practices not only pointed up the patent artifice of fluoridated water but also steered the arguments away from terms and terrain on which fluoridation science had evolved: dose-response curves between fluoridated water and pathology, forged on populations elsewhere. All of the practices antifluoridationists deemed natural had histories, likely including recommendations by earlier experts; the timeless, static cast of their appeals to "nature" was thus deceptive, to contemporary social scientists and many antifluoridationists themselves. Naturalism absolved them from delving into the personal histories that solidified their confidence in certain ways of handling their families' water, food, and medicine; at the same time, it affirmed the importance of *these* histories to the fluoridation issue. Even if extending back to childhoods elsewhere, in contrast to the messages of either fluoride scientists or traveling antifluoridationists, these histories were more localized, more these suburbanites' own.

Antifluoridationists' more ecologically-based questions about fluoridation science proved prescient. Braking the spread of fluoride through public water pipes, antifluoridation channeled a flood of fluoride into Americans' bodies through private consumption—drugstores and supermarkets rather than water faucets. In toothpastes, mouthwashes, and vitamin supplements, fluoride rapidly evolved from a marketing tool to a near prerequisite for American manufacturers. By the mid-1980s, 90 percent of toothpaste sold in America contained fluoride. The fluoride choices available to American consumers when it came to toothpaste verged on the compulsory—just what antifluoridationists had feared from state-fluoridated water.[50] Though controlled community studies have continued to confirm the preventive effects of mildly fluoridated water on tooth decay, the impacts measured more recently have been two-thirds to one-half of what PHS scientists measured in the 1940s. The reasons cited are largely what early antifluoridationists anticipated. With so many toothpastes and mouthwashes now prepared with fluoride supplements, and with so many foods prepared with fluoridated water, even those Americans without fluoridated drinking water take in much more fluoride than did their 1950s counterparts.[51]

CONCLUSION

Examining the historical ontology of fluoridated water among these three separate groups over the mid twentieth century highlights not so much their borrowing from as

[49] Pure Water Committee, "Protect Our Children's Teeth" (cit. n. 41); Clara Harban, letter to editor, "Why Fluoridation?" *Manhasset Press,* 10 April 1958.

[50] E. D. Beltran and S. M. Szpunar, "Fluoride in Toothpastes for Children: Suggestion for Change," *Pediatric Dentistry* 10 (1988): 185–8.

[51] Alan Hinman, Gene Sterritt, and Thomas Reeves, "The US Experience with Fluoridation," *Community Dental Health* 13 (1996): S5–9.

their indifference to one another. If American fluoridation science drew heavily upon the European literature early on, it was largely by ignoring, rather than addressing, the findings of Indian scientists that U.S. scientists concocted such a strong case for fluoridation. Lay Manhassetites, bolstered by confidence in their own personal experiences—often local, longstanding, and homebound—turned a deaf ear not just to American fluoridation experts but to an Indian science of skeletal fluorosis, despite the number of traveling antifluoridationists who took it as ammunition for their side. Most responsive among these three groups were the Indian scientists, whose findings ran against the grain of the quickly proliferating studies of American profluoride scientists. The recalcitrant, widening presence of skeletal fluorosis nevertheless helped sustain the Indian ontology of fluoridated water in a very different orientation from its American counterpart, as more problem than solution.

If a geographically circumscribed historicism illuminates the peculiar ontology of each group, careful readers will note how I have brought their indifferences alongside one another precisely by rooting each within a larger environmental history of fluoride's varied distribution and flow. What we might term an environmental symmetry linked their separate, distant locations, between an America "naturally" fluoridated only in pockets, where fluoridation took shape as a public health project, and the highly fluoridated countryside where Indian scientists uncovered skeletal fluorosis. Even in Manhasset-Lakeville itself, among lay antifluoridationists who played such key roles in steering fluoride's spread, minimal fluoride levels shaped the strengths as well as the weaknesses of their arguments. Their ontology from unfluoridated personal experience invited self-consciously "natural" labels for diet, drink, and spillage, along with an integrative analysis that we can, in retrospect, identify as ecological. But fluoride's diseases proved more fleeting and unstable in this lay ontology than for either group of scientists; without local or personal memories of fluoride's actual effects, Manhasset-Lakeville and other communities were forced to choose between more or less distant and competing echoes of the effects of fluoride ingestion. That so many did embrace fluoride's merits, unlike Manhassetites, had profound longer-term consequences on fluoride's global circulatory system. Over the late twentieth century, a gathering stream of fluoride passed through supermarkets and water pipes within America and beyond, raising fluoride exposures worldwide.[52]

The impacts of this human-mediated tide have been felt among investigators in both nations. American scientists' version of fluoride has destabilized in important ways, forcing questions that their predecessors had thrust aside. As rates of dental fluorosis have grown in many fluoridated communities, as environmental laws, agencies, and health disciplines have also expanded, health scientists and advisory committees have turned to emphasizing "the influence of sources of fluoride other than water," especially diet. A few confirmed cases of skeletal fluorosis in the United States, along with studies of fluoride's effects on cancer and reproduction, helped spur the U.S. Environmental Protection Agency to set new maximum drinking-water standards for fluoridated water. In specialized publications, some U.S. as well as Indian scientists still puzzle over why there were so many fewer cases of skeletal fluorosis in America than in India when exposures were comparable. Yet only starting in the late 1990s did

[52] C. E. Renson, "Changing Patterns of Dental Caries: A Survey of 20 Countries," *Annals of the Academy of Medicine of Singapore* 15 (1986): 284–98.

editions of prominent textbooks in environmental medicine and preventive dentistry make any mention of crippling pathologies of fluoride beyond American shores.[53]

In India, despite redoubled efforts to defluoridate water supplies, the risk of skeletal fluorosis has grown and spread as more people partake of dentifrices, beverages, and other goods from the fluoridated West. Outside the medical centers specializing in skeletal fluorosis, Indian public health officials are frustrated in their efforts by the limited awareness of this disease among local doctors and health officers. Not just material flows of fluoride, but the cultural flows of textbooks and other medical and dental literature from the West, which ignore this endemic disease and tout water fluoridation, stand in the way of taming its ravages.[54] On the far side of the globe, the most fearful imaginings of antifluoridationists have become a dreadful reality.

[53] Ibid., 46–47; National Research Council, Subcommittee on Health Effects of Ingested Fluoride, *Health Effects of Ingested Fluoride* (Washington, D.C., 1993); William Rom, *Environmental and Occupational Medicine* (Philadelphia, 1998), 1078; Norman Harris and Franklin Garcia-Godoy, *Primary Preventive Dentistry* (Stamford, Conn., 1999), 169; Institute of Social Sciences, *Fluorosis in India* (cit. n. 2).

[54] Institute of Social Sciences, *Fluorosis in India* (cit. n. 2), 38–9, 91.